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GROUNDWATER GEOLOGY IN SOUTH-CENTRAL ILLINOIS

A Preliminary Geologic Report

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Service activities concerning groundwater are performed jointly by the Illinois State Geological Survey and the Illinois State Water Survey.

DIVISION OF THE
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ABSTRACT

Possibilities for developing domestic, farm, municipal, industrial, and irrigation groundwater supplies in south-central Illinois range from poor to excellent. This report presents a general summary of groundwater principles, summarizes the geologic factors that control the availability of groundwater, and discusses methods of developing groundwater supplies.

The maps show 1) probability of occurrence of sand and gravel aquifers and 2) areal distribution, type, and water-yielding character of upper bedrock formations.

INTRODUCTION

We can appreciate the role that water plays in the economy of the state when we think of the billions of gallons of water that are required daily by farms for crops and livestock, by industries for cooling, processing, and power generation, and by cities for household use and public services. Recent estimates indicate that Illinois uses 8 billion gallons of water per day for industrial purposes, excluding power generation, and about 1.5 billions for municipal and domestic purposes (Illinois State Chamber of Commerce, 1956).

On farms, crops use the major amount of water; for example, a bushel of corn requires about 6000 gallons of water and a bushel of soy beans requires about 11,000 gallons of water from planting to harvest. In Illinois nearly all agricultural water, about 33 billion gallons a day, comes from soil moisture. Water, therefore, is as basic to the economy of Illinois as are its mineral deposits and rich soils.

This report provides information on the availability of groundwater for farm, industrial, and municipal supplies in south-central Illinois and discusses principles of groundwater occurrence and development. It is the sixth of a series* in a program aimed toward improving water supplies on Illinois farms. The Illinois State Geological Survey is cooperating with the Extension Service of the Agricultural Engineering Department, College of Agriculture, University of Illinois, in this program.

This report covers the following 18 counties (figs. 1 and 3) of Agricultural Extension District No. 4: Bond, Clark, Clay, Clinton, Crawford, Cumberland, Effingham, Fayette, Jasper, Lawrence, Macoupin, Madison, Montgomery, Marion, Monroe, Richland, Shelby, and St. Clair. This region, which extends from the Mississippi River to the Wabash River, comprises 9,784 square miles and has a population of about 743,500. It includes a large area of highly productive agricultural land on which dairy and general farming are the principal enterprises. The main industrial cities are East St. Louis, Alton, Cen-

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*Previous reports in the series, listed in suggested reading on page 27 and shown in figure 1, are available, upon request, from the Illinois State Geological Survey in Urbana.

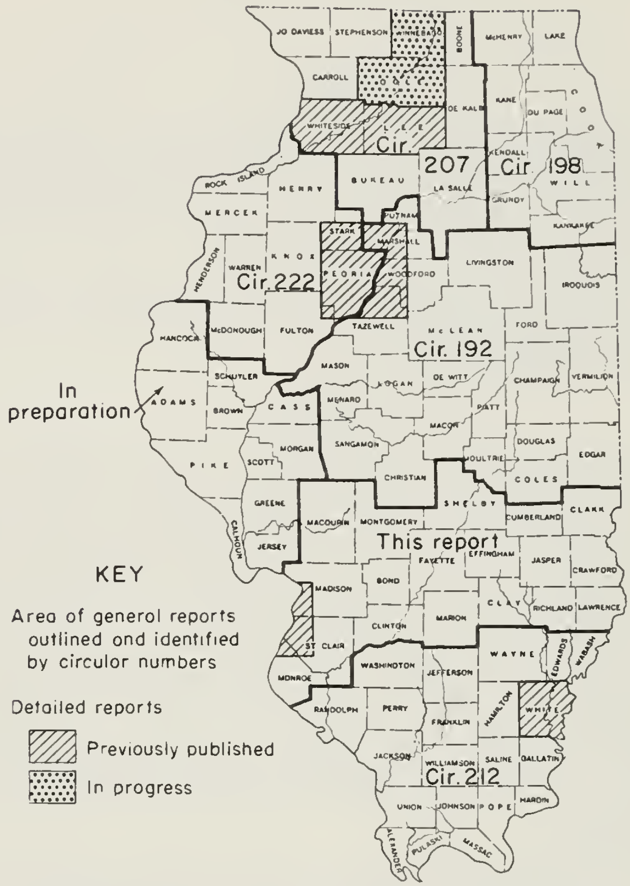


Fig. 1. - Index map of reports of groundwater geology in Illinois published since 1950 or in progress.

tralia, and Effingham. Major oil fields, such as Salem Consolidated in Marion County, Clay City Consolidated in Richland and Jasper counties, Louden Consolidated in Fayette County, and Main Consolidated in Lawrence, Crawford, and Clark counties, are in this region.

In south-central Illinois the Mississippi, Wabash, Little Wabash, and Kaskaskia rivers provide large quantities of surface water. The total area in which surface water is available is relatively small so that most farms, suburban communities, and industries obtain water from wells - that is, groundwater. Therefore the availability of groundwater is of great economic importance.

The nature of earth materials beneath the surface largely controls the availability, quantity, and quality of groundwater. Groundwater supplies are obtainable only where there are subsurface beds that can transmit water to a well and provide a source of recharge. Beds that transmit water are permeable and are called aquifers. Because geologic conditions change laterally, groundwater is readily available in some areas, whereas in other areas it is

difficult to obtain even small supplies. The proper development of groundwater resources of an area, therefore, requires information on the distribution and character of the aquifers that may be present.

The authors wish to acknowledge the helpful assistance given by the drilling contractors in providing large numbers of logs of water wells in south-central Illinois for the files of the Illinois State Geological Survey and in supplying information on specific problems of occurrence of water-yielding materials and drilling conditions.

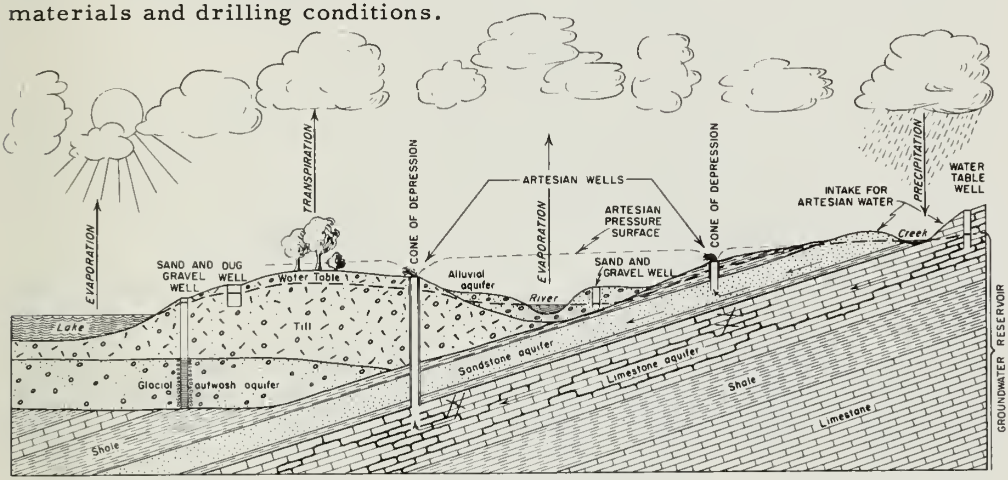


Fig. 2. - Source, movement, and occurrence of groundwater.

OCCURRENCE OF GROUNDWATER

Throughout history many explanations have been presented for the source, movement, and occurrence of groundwater. Because groundwater occurs beneath the earth, hidden from view, many myths and legends have developed regarding it. Scientific study has shown, however, that groundwater obeys physical laws or principles that are relatively simple and easily understood although they may be complex in detail. Figure 2 shows diagrammatically the basic fundamentals of our present understanding of the source, movement, and occurrence of groundwater.

Groundwater is supplied by seepage into the earth of some of the moisture that falls as rain, snow, and ice. The tremendous quantity of water that falls on the land surface by precipitation is seldom fully realized. A simple calculation shows that one inch of rainfall distributed over one square mile is nearly 17 1/2 million gallons. However, only a small part of precipitation actually enters the groundwater reservoir. Most of it falls into oceans, runs off in streams, or is returned to the atmosphere by evaporation and transpiration. The remainder filters slowly into the ground to a level below which all available openings are filled with water.

The top of this saturated zone is called the water table. If a well is drilled or dug it remains dry until it penetrates the zone of saturation; the position of the water table is then shown by the level at which water stands in the well.

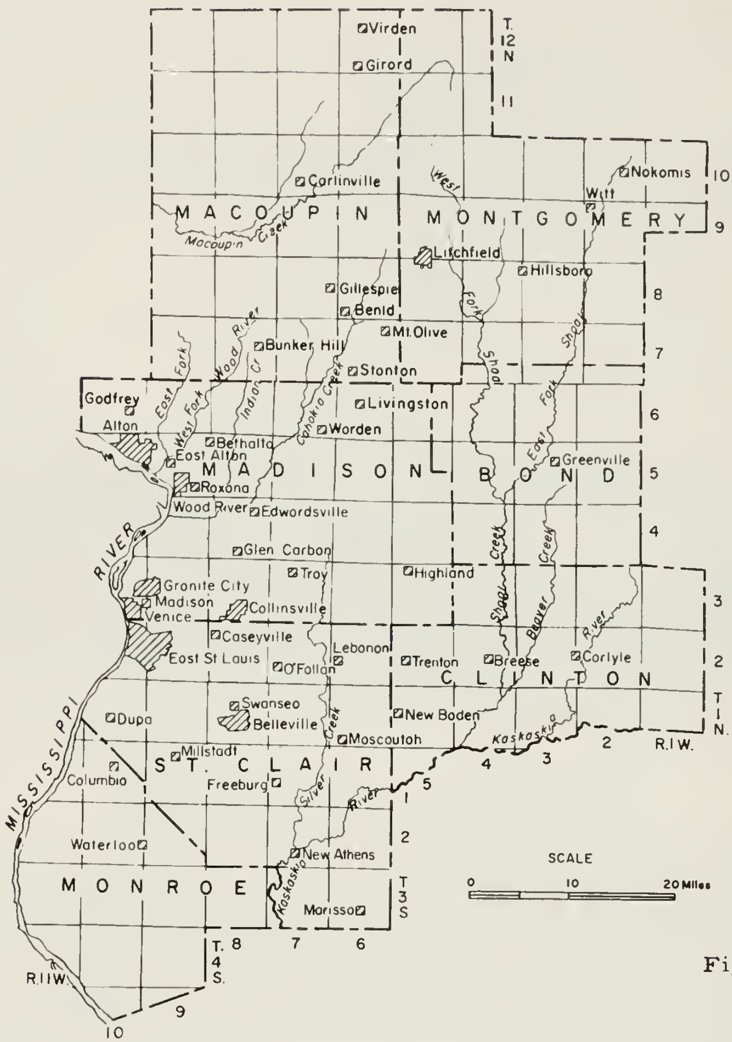
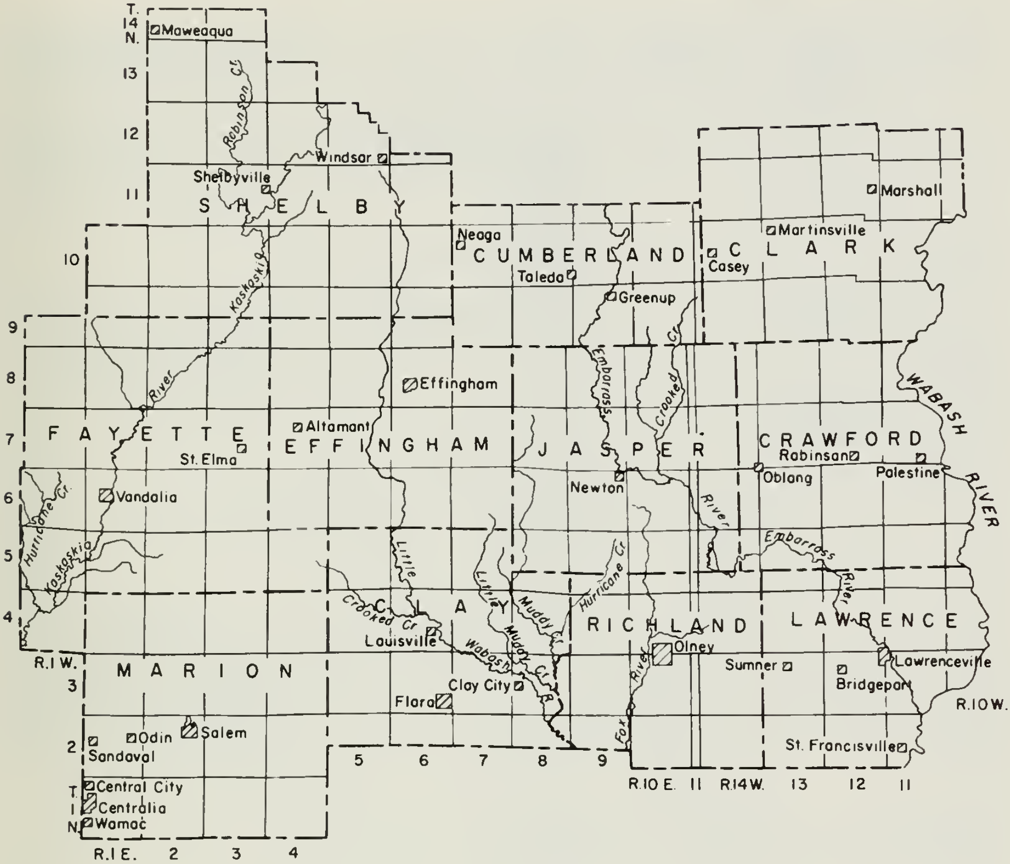


Fig. 3. - South

The water table conforms more or less to the topographic features of the land surface. Where the water table intersects the land surface, groundwater is discharged in the form of springs, which feed perennial streams, lakes, and swamps. The water table fluctuates in response to the loss or gain of groundwater in the reservoir and the water level in a well reaching the saturated zone ("water-table" well) fluctuates with the water table. During extended dry periods shallow wells may go dry because the water table drops below the bottom of the well.

Groundwater moves under the influence of gravity or in response to other pressure differentials toward points of lower pressure, which are places of discharge, such as springs or discharging wells. This movement is slow, in part because there is friction between the water and the pore or crack surfaces.



central Illinois.

Groundwater is said to be under water-table conditions where it is under only atmospheric pressure. Under these conditions and under the control of gravity, groundwater moves freely, hindered only by friction, in the direction of the slope of the water table.

Groundwater is said to be confined or under artesian conditions where a saturated aquifer is overlain by a less permeable material that restricts the upward movement of the groundwater. Under these conditions the water in the confined strata has a natural pressure that causes the water in a well to rise above the top of the aquifer. Where sufficient pressures are encountered in an artesian well, the water may rise above the land surface, causing the well to flow.

To supply a pumped or flowing well, groundwater must move through the aquifer toward the well. Under water-table conditions, pumping lowers the

SYSTEM	SERIES OR GROUP THICKNESS	FORMATION	GRAPHIC LOG	ROCK TYPE	WATER-YIELDING CHARACTERISTICS; DRILLING AND WELL CONSTRUCTION DETAILS
	Pleistocene 0-200			Unconsolidated glacial deposits, windblown silt (loess), and alluvium	Thick sand and gravel deposits source of large supplies in major stream valleys. Thin upland sand and gravel deposits locally suitable for small supplies. Requires testing, screens, and development
PENNSYLVANIAN	McLeansboro 0-1000			Shale, sandstone, limestone, and coal	Water-yielding character variable. Locally shallow sandstone and creviced limestone yield small supplies. Water quality usually becomes poorer with increasing depth. May require casing.
	Carbondale 0-300				
	Tradewater-Caseyville 0-1100				
MISSISSIPPIAN	Chester 0-1300	Kinkaid Degonia Clore Palestine Menard Baldwin: Waltersburg, Vienna, Tar Springs Okaw: Glen Dean, Hardinsburg, Golconda Ruma: Cypress Paint Creek Yankeetown: Bethel Renault Aux Vases		Limestone, sandstone, and shale	Some sandstones, particularly Aux Vases, are important sources of groundwater in Madison, St Clair, and Monroe counties. Limestone may yield domestic supplies. Too deep in eastern and central part of area to yield potable water. Shales may require casing
	Valmeyer 520-1500	Ste Genevieve St Louis Salem Warsaw Burlington-Keokuk Fern Glen		Limestone, dolomite, and shale	Dependable aquifer for small to medium supplies in Madison, St Clair, and Monroe counties. St Louis limestone particularly favorable. Crevices and solution channels may cause drilling difficulties
	Kinderhook 0-250			Shale	Not water-yielding
DEVONIAN	0-200			Limestone, dolomite	May yield groundwater from joints and channels. Too deep to yield potable water.
SILURIAN	0-1000			Limestone, dolomite	
UPPER ORDOVICIAN	510±1300±	Maquoketa Kimmswick-Plattin-Joachim St Peter		Shale, dolomite, and sandstone	Dolomite may yield water in Mississippi River flat in Monroe county. Water in St Peter sandstone highly mineralized
LOWER ORDOVICIAN AND CAMBRIAN (extends down to crystaline basement rock)					

Fig. 4. - Rock units in south-central Illinois.

water table in the vicinity of the well and induces groundwater to flow toward the well from adjacent areas. Under artesian conditions, pumping reduces hydrostatic pressure in the vicinity of the well, which induces the flow of groundwater toward the well. The depression in the water table, or in the artesian pressure surface resulting from discharge, is in the form of an inverted cone with the well at the center and is called the cone of depression (fig. 2).

Although water is to be found everywhere below the top of the saturated zone, it is not everywhere available for withdrawal. Successful wells can be constructed only where strata are present that will easily transmit water. The capacity of earth materials to absorb, store, and yield water depends on the type, size, number, and degree of interconnections that can store and conduct groundwater. Some earth materials, such as sand and gravel, have characteristics that make them particularly good aquifers. Other earth materials, such as clay and shale, may contain as much water per cubic foot as sand and gravel, or even more, yet may resist the movement of groundwater through them to such a degree that they will not yield water to a well.

In south-central Illinois the most important aquifers are deposits of sand and gravel above the bedrock, and limestone and sandstone beds in the bedrock (figs. 4 and 5).

Sand and gravel deposits are usually water-yielding because the openings between the grains are large enough to allow relatively free movement of water. The most permeable water-yielding sand and gravel deposits are composed of particles that are nearly all the same size and coarser than granulated sugar. If silt and clay occupy the spaces between the larger particles of sand and gravel they retard the flow of water.

Sand and gravel deposits in south-central Illinois are from a few inches to about 50 feet thick. Deposits a few feet or more thick are often suitable aquifers for drilled wells. Thinner deposits of sand and gravel may be suitable only for large-diameter dug or augered wells.

Sandstone formations also transmit groundwater through the openings between sand grains. As in sand and gravel deposits, the water-yielding capacity of sandstone depends upon the size and sorting of the sand grains. Any material in the openings between the sand grains reduces the water-transmitting capacity of the sandstone. Some sandstones are so thoroughly cemented that water moves through joints and fractures rather than between grains.

Sandstone strata in the Pennsylvanian system in south-central Illinois are generally fine-grained, in part cemented, and have relatively low permeabilities. The Mississippian sandstones, particularly the Aux Vases (fig. 4), are generally less cemented and are better sorted so that where they are present and contain fresh water they are better aquifers than Pennsylvanian sandstones.

Limestone and dolomite rocks are generally tight and compact, and transmit groundwater only through cracks and solution channels. Wells drilled into these rocks are successful if the well penetrates water-bearing crevices. Because in limestone and dolomite the occurrence of these openings is irregular, their presence at any specific location is difficult to predict.

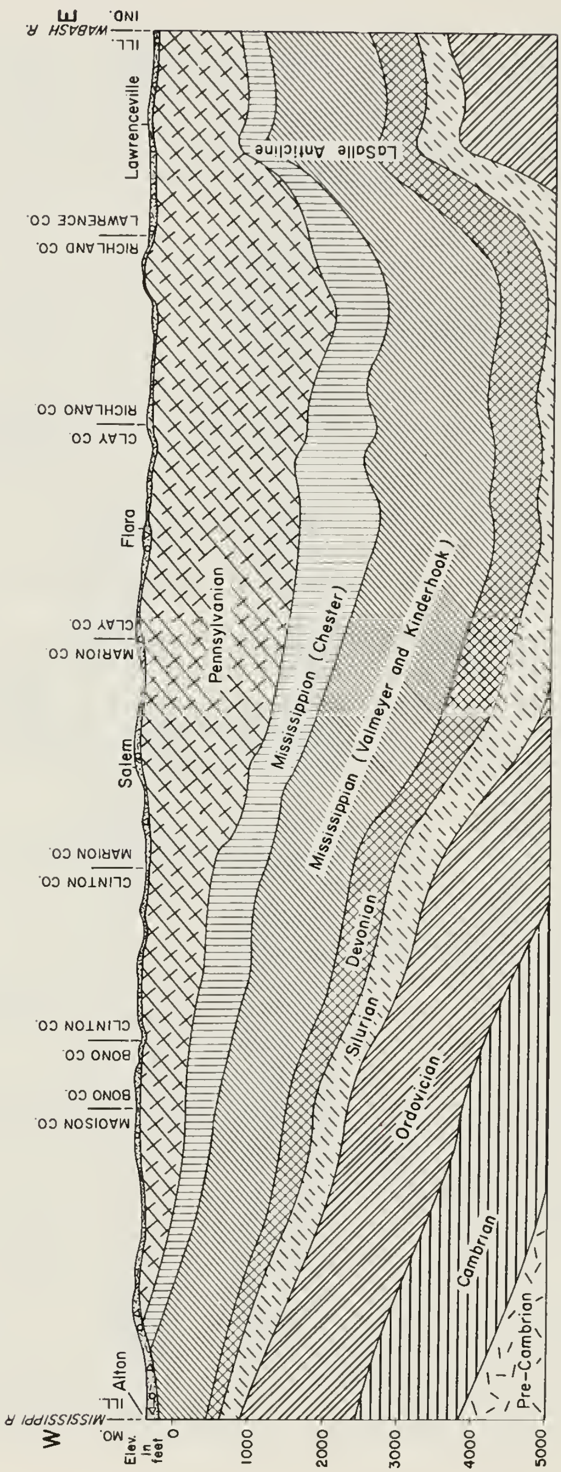


Fig. 5. - Cross-section of south-central Illinois.

The St. Louis and the Burlington-Keokuk limestones (fig. 4) are much creviced at most places and are usually a dependable source of groundwater for farm and domestic supplies where they contain fresh water.

GEOLOGY

The land surface of south-central Illinois has been shaped principally by running water and glacial ice. Running water is modifying the surface today by cutting into the land, carrying away soil and rock particles, and depositing the debris in river bottoms. The features produced by glacial ice were developed long ago.

Glaciers, nourished by snow accumulation in Canada, several times advanced across Illinois and melted away leaving behind a vast quantity of rock debris. Unsorted clay, silt, sand, and pebbles laid down under the advancing ice or dumped during melting is called till. Beyond the ice front, sediment-laden meltwaters escaped down valleys, partially filling them with deposits of sorted sand, gravel, and finer material, called outwash. River flats, kept free of vegetation by frequent glacial flooding, were subject to wind erosion, and great volumes of silt were blown onto the uplands bordering the valleys to form loess deposits. Till, outwash, loess, and the sediment of modern streams cover the bedrock surface in most of south-central Illinois, resulting in a relatively level plain.

The surface of this plain, south of the edge of the latest (Wisconsin) glaciation (fig. 6), is broken only by isolated knobs and ridges and by stream dissection. The highest land elevations are in the northern part of the area where at the south margin of the Wisconsin glaciation (fig. 6) a low rolling ridge, the Shelbyville moraine, was formed at the front of the ice.

Information from wells and exposures of bedrock at the land surface indicate that the bedrock has an irregular surface formed by erosion prior to glaciation. Some of the bedrock valleys coincide with present stream valleys but some are partly or completely buried and there is little or no evidence of their presence at the surface.

The bedrock in south-central Illinois consists of beds of shale, sandstone, limestone, and dolomite arranged one upon the other (figs. 4 and 5). The beds originally were deposited as unconsolidated sediments in shallow seas or bordering marshes. The sediments were buried and hardened into solid rock during the several hundred million years after the seas retreated from Illinois. The rocks were later warped and in some places broken. In south-central Illinois the beds form part of a saucer-like structure known as the Illinois basin (fig. 5). The deepest part of the basin is in White County (fig. 1), where rock layers that are at the surface along the Mississippi River lie at a depth of several thousand feet. In the eastern part of the basin there is a narrow band along which the rocks have been warped upward into an arch-like structure or anticline (fig. 5). This structure, the LaSalle anticlinal belt, extends from Ogle County to Wabash County (fig. 1). Accumulations of oil along this belt in south-central Illinois are of great economic importance.

A few very deep borings show that the bedrock strata rest on a basement of ancient crystalline rocks composed mainly of granite. An oil test in Monroe County, near East St. Louis, encountered granite at a depth of 2,560 feet.

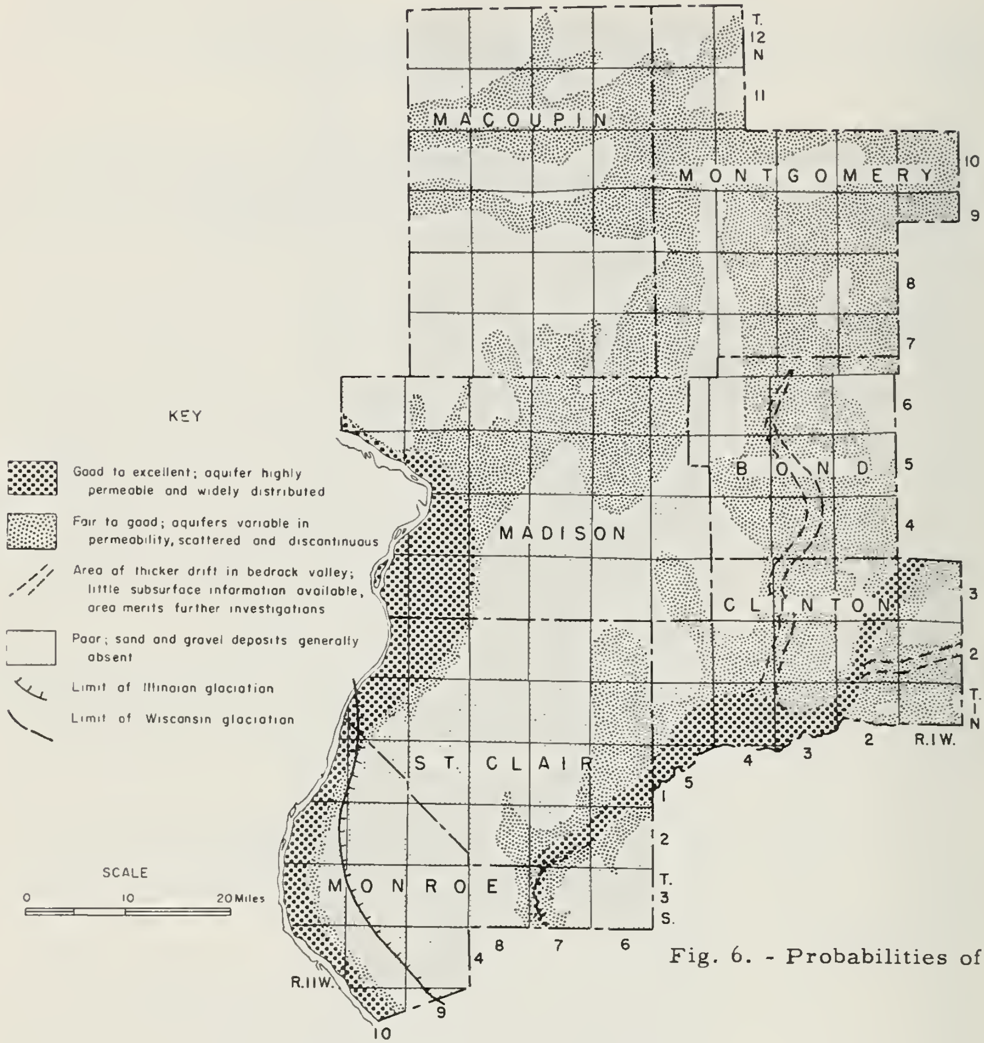


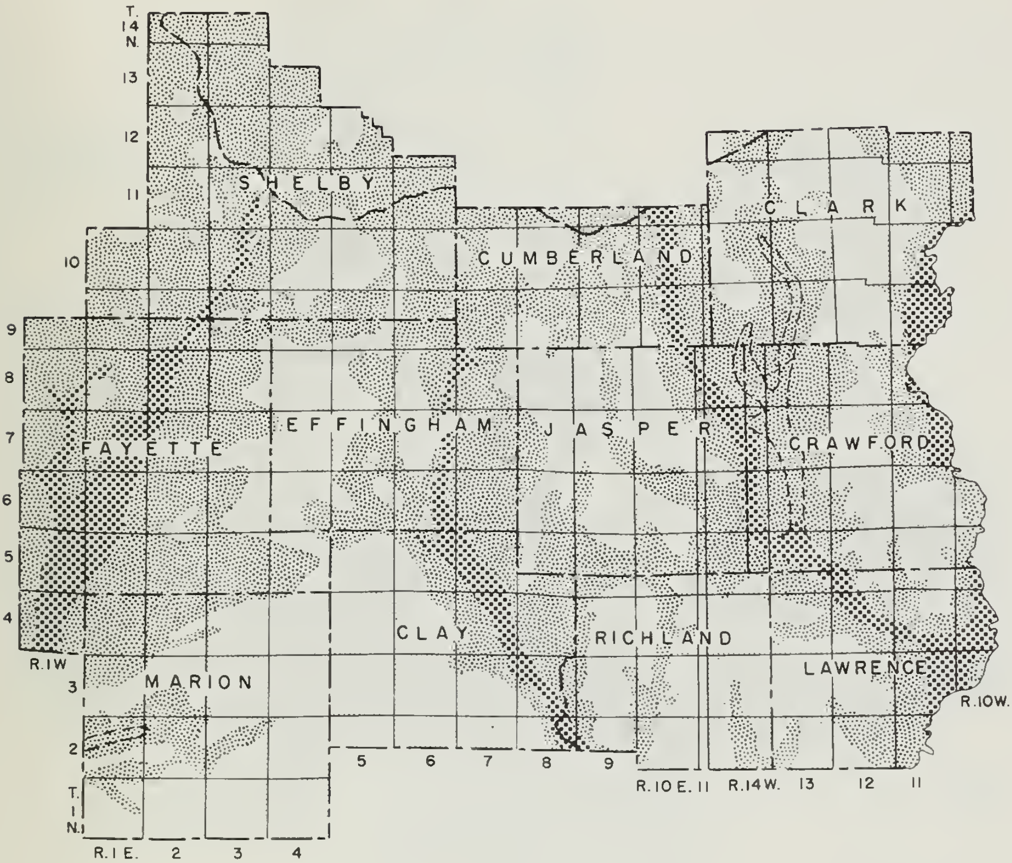
Fig. 6. - Probabilities of

Depth to basement is estimated to be about 12,000 feet at Carmi, near the deepest part of the Illinois basin.

DISTRIBUTION OF AQUIFERS

Sand and gravel deposits occur in the unconsolidated material that glaciers and running water have deposited on the bedrock surface (figs. 3, 4, and 6). Sandstone, limestone, and dolomite occur in the bedrock (figs. 3, 4, and 7).

Sand and gravel deposits merit careful consideration as a source of groundwater, particularly along the courses of streams or in preglacial buried valleys. Figure 6 shows the probability of occurrence of sand and gravel aquifers. The area labeled "good to excellent" is underlain by thick deposits of unconsolidated material containing sand and gravel. In this area



occurrence of sand and gravel aquifers.

groundwater for domestic and farm supplies may be obtained easily with small-diameter drilled wells. The probabilities for construction of high-capacity wells for industries and municipalities are good, although test drilling is necessary to locate suitable sand and gravel deposits.

The area labeled "fair to good" in figure 6 is underlain by moderate thicknesses of unconsolidated materials filling shallow valleys or on the uplands bordering the main valleys. These materials contain thin and discontinuous deposits of sand and gravel. Groundwater for domestic and farm supplies is obtained locally in this area from wells drilled in sand and gravel, but in some places good water-yielding deposits are absent and water from the unconsolidated material is obtainable only with large-diameter dug wells. The probabilities of obtaining supplies of water for industrial and municipal

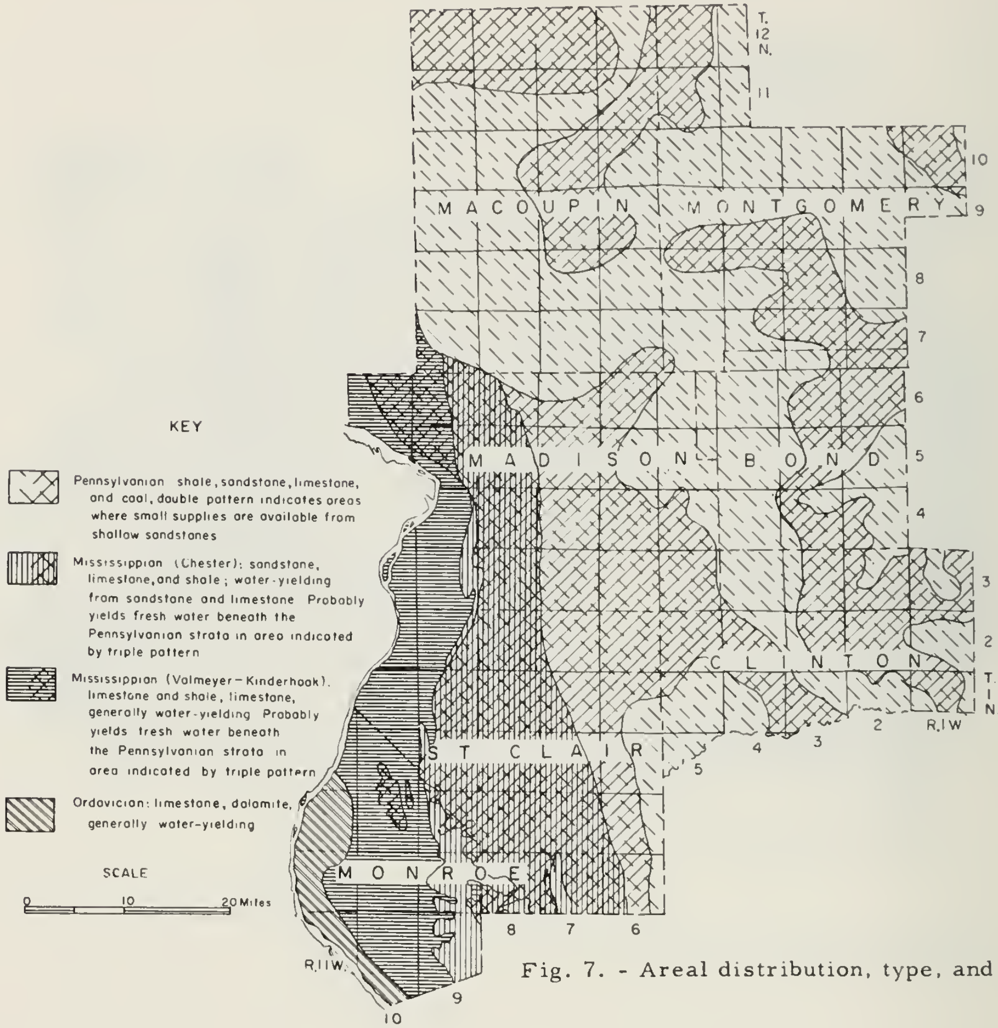
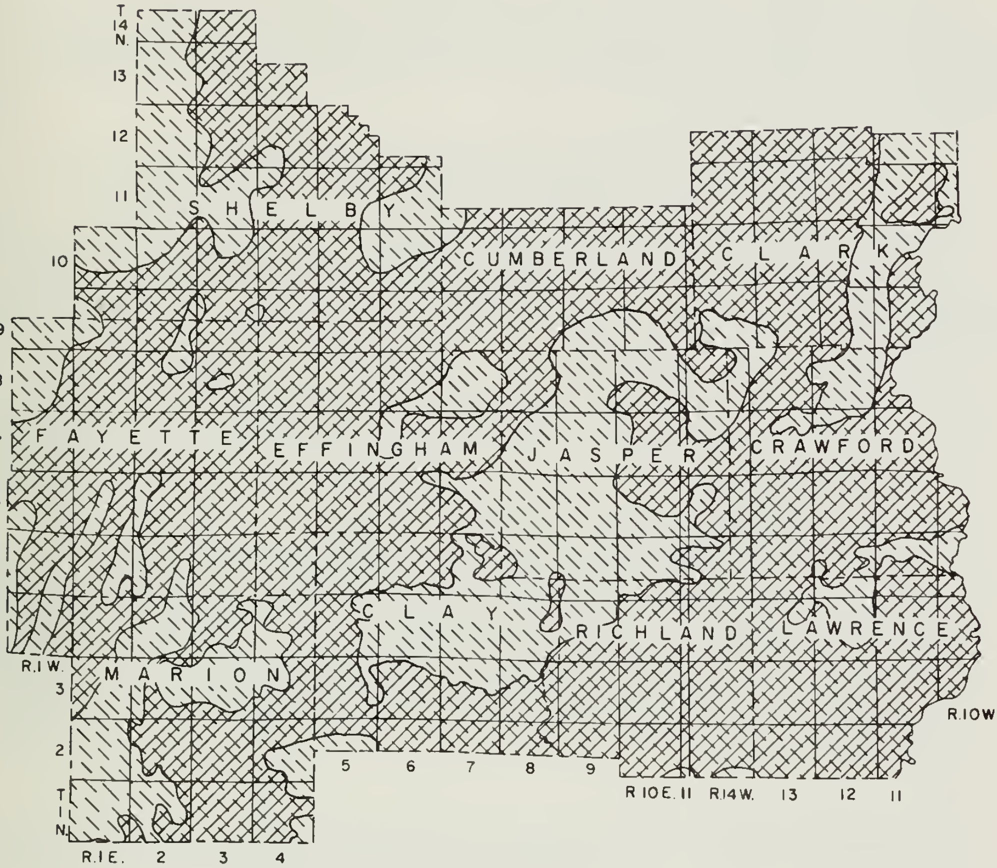


Fig. 7. - Areal distribution, type, and

purposes are poor to fair. Extensive test drilling generally is necessary to locate water-yielding deposits. The areas outlined by dashes in figure 6 correspond to buried bedrock valleys that contain deposits of unconsolidated material up to 180 feet thick. Few well records are available in these areas and therefore the extent of sand and gravel deposits is not known. These areas merit special attention in exploration for water-yielding sand and gravel.

The area labeled "poor" is primarily bedrock upland with glacial deposits thin or absent. Sand or gravel streaks capable of supplying groundwater are rare and most wells obtain water from the bedrock.

Figure 7 shows the distribution and water-yielding characteristics of the bedrock formations that crop out at the surface or lie directly beneath the glacial and alluvial materials. The areas within the Pennsylvanian boundary,



water-yielding character of upper bedrock formations.

which are shown as favorable for groundwater, are underlain by sandstone aquifers in which the possibilities for domestic and farm water supplies are fair to good.

The determination of the favorable areas was based on the study of water-well records and of a great number of electric logs of oil-well tests. The areas shown as unfavorable include a few areas in which no information was available at the time of the preparation of this report.

Although sandstones are the most reliable source of groundwater, small supplies of groundwater can be obtained locally from creviced limestones and from cracked shale and coal. Therefore, throughout south-central Illinois testing of the upper part of the bedrock for the presence of thin permeable sandstones or other water-yielding materials is generally recommended.

Mississippian limestones and sandstones are suitable sources of groundwater for domestic and farm supplies where they are present immediately below the unconsolidated material or where they are covered by thin Pennsylvanian formations. Locally, the Mississippian aquifers may yield larger quantities of groundwater.

DEVELOPMENT OF GROUNDWATER SUPPLIES

Geologic Conditions that Affect Groundwater Development

The geologic factors that control the amount and quantity of groundwater available in an area and that must be considered in developing groundwater supplies are:

1) Distribution, depth, thickness, and areal extent of aquifers.
2) Nature of aquifers, including type of materials, kind of openings (pores or crevices), and presence of substances that affect water quality.
3) Geologic structure, including regional and local dips of beds, faults, and jointing.
4) Distribution and nature of relatively impermeable materials.

The fact that an aquifer is present in a given area does not guarantee that a satisfactory groundwater supply can be obtained from it. Care must be taken to select the aquifer most suitable for the water supply required, to adapt the type and manner of construction of the well to the geologic conditions, and to place the well where it will best maintain the required standards of quality and quantity of water.

Unconsolidated Deposits

Generally if water-yielding sand and gravel deposits are present in an area, attempts should be made to develop wells in them rather than in the underlying bedrock. Some of the advantages of utilizing sand and gravel wells are 1) less lift because of shallower water levels, 2) colder water, 3) generally greater water yield per well, and 4) in some areas water of better mineral and bacterial quality. The chief disadvantage of sand and gravel wells is that special construction is needed to take full advantage of the water-yielding capacity of the aquifer.

Sand and gravel wells require the use of screens, and often a gravel envelope, to allow the free flow of water into the bore and to prevent intrusion of sand and gravel. Better results and yields are nearly always obtained from sand and gravel deposits by placing an envelope or pack of selected gravel or coarse sand between the deposit and the screen. The use of open pipe, slotted pipe, or pipe filled with gravel should be avoided except in very coarse deposits that will yield far more water than is pumped.

Development necessarily follows construction of a sand and gravel well. It is important in the development of sand and gravel wells that the size of the screen openings or slots be chosen on the basis of the size of the material to be screened and of the particle size of the gravel pack. Therefore it is neces-

sary that samples of the aquifer be obtained and analyzed for particle size to determine the correct screen opening. For proper development, the finer grained materials in the immediate vicinity of the well bore should be removed to leave a natural graded filter that will reduce or prevent pumping of sand and silt.

The physical characteristics of sand and gravel deposits generally are more variable than those of the bedrock formations. For this reason groundwater development from sand and gravel sources commonly requires test drilling prior to choice of well design and construction. In areas in which the presence and distribution of suitable aquifers is in doubt, a test-drilling program is necessary to determine whether deposits suitable for the specific need are present and, if present, the best location for the well site.

A test-drilling program should be started only after all geologic data have been studied for indications of where test holes should be placed, When sufficient geologic data are lacking, additional information concerning the location, distribution, and extent of aquifers may be obtained by geophysical methods such as earth-resistivity and seismic surveys.

An area generally is tested by drilling small-diameter holes with rotary or cable-tool (percussion) equipment. The test driller's report is an important part of the development program and should include the following information: 1) driller's log of formations penetrated, 2) static water levels and changes in level during drilling, 3) drilling time per interval (2 to 5 feet) of the individual formations, 4) weight and viscosity of drilling fluid, 5) amount of drilling fluid lost during drilling, and 6) approximate depth of hole at time of fluid loss. Samples of drill cuttings should be saved at regular intervals of 5 feet or less and at changes in formation.

In south-central Illinois conditions favorable for drilled wells in sand and gravel are found mainly in and along the Mississippi, Kaskaskia, Embarrass, Wabash, and Little Wabash river valleys (fig. 6).

Driven wells are the most quickly and economically constructed. They are practical where only small supplies of groundwater are needed and where such supplies may be available from sand and gravel at shallow depths. Conditions are locally suitable for driven wells in the bottomlands of the Mississippi, Wabash, and Kaskaskia rivers.

Large-diameter dug wells are most suitable in areas where the unconsolidated materials are fine-grained and cannot yield water readily to a drilled or driven well. They therefore are used widely throughout much of the area in which glacial material is thin and tight and is underlain by relatively impermeable Pennsylvanian rocks. Large-diameter wells are excavated by hand or by power auger, shovel, or bucket and can be excavated to depths to 100 feet. In areas in which conditions are favorable for drilled or driven wells, the use of large-diameter dug wells is not recommended because of pollution and maintenance problems. The chief advantage of a large-diameter well is that it can store relatively large quantities of water. Short, intermittent pumping of a large-diameter well does not require immediate release of water from the surrounding materials, and the well can refill slowly in sev-

eral hours. Special sanitary precautions should be taken with large-diameter wells (Circular 14, Illinois State Department of Public Health, Springfield).

Bedrock Formations

Wells constructed in bedrock aquifers generally are less difficult to design because the well bore generally is left uncased and because the aquifers are more consistent over wider areas. Test drilling in bedrock aquifers is seldom done, particularly when records of prior drilling in the area are available.

In south-central Illinois, geologic factors affecting well construction in bedrock aquifers are 1) type, thickness, depth, and permeability of aquifers, 2) tendency of formation to sustain open hole without casing or lining, and 3) tendency of formations to yield silt or sand during pumping.

Creviced limestone and dolomite do not require casing or lining. However, where groundwater supplies are obtained from creviced formations having a thin unconsolidated cover the water may be polluted. Open crevices provide little if any filtering action so that polluted water may travel long distances through the openings. In the sinkhole region in Madison, St. Clair, and Monroe counties where limestone is at the surface or below a thin layer of unconsolidated material, wells that penetrate shallow, cavernous limestone must be constructed with special attention to sanitary practices (Education Health Circular 14, Department of Public Health, Springfield).

In developing bedrock aquifers normal drilling procedure is to install surface casing to firm bedrock and continue into the bedrock with an open hole. Where bedrock formations are too weak to sustain an open hole, it may be necessary to continue the surface casing through the weak formation into a more competent underlying formation or to set liners. The most important caving zones that require casing are in the Pennsylvanian and Warsaw shales, and at some localities the shales of the Chester series (fig. 4).

In some limestones, especially in the Valmeyer series, holes tend to become crooked during drilling and thus may present unavoidable difficulties.

It is not always possible to avoid pumping some mud, silt, or sand from high-capacity wells, but when the fine materials become excessive remedial measures must be taken. The Illinois Geological Survey frequently assists in solving this problem by identifying the source and approximate depth of the materials, so that casing or liners can be installed at the proper positions and thus reduce or eliminate the discharge of materials. The most common sources of materials pumped with water are 1) silt and clay from overlying glacial deposits which enter through leaks in surface casing or improperly seated surface casing, 2) silt and clay from weak shale or underclay zones that have been left uncased or are improperly cased, 3) clay and silt from open crevices and caves in the limestone, quite common in some areas, and 4) silt and fine sand from fractured sandstones.

Most of these problems can be corrected by installing casing or liners. In sandstone formations, however, casing may materially decrease the well yield. There are three common causes of excessive silt and sand pumpage from sandstone formations:

1) Drilling too small a hole in loose sandstone formations. The smaller the diameter of the well bore, the greater the velocity

of water moving through the formation immediately around it. Enlarging the diameter of the well bore or reducing the pumping rate decreases the velocity of water movement.

2) Setting the pump bowls opposite unprotected loose zones in the sandstone. Turbulence in the vicinity of the pump bowls causes enlargement of the hole.
3) Shooting loose sandstone zones with too much explosive and with too little regard for the condition of the sandstone.

Conditions for drilled wells in the bedrock in south-central Illinois are locally favorable. The main aquifers exploited for farms and domestic supplies and locally for larger supplies are Mississippian limestones and sandstones in the western part of the area and shallow Pennsylvanian sandstones in the central and eastern parts (fig. 7). Because the Pennsylvanian sandstones differ laterally in permeability they are not water-yielding at all sites. In south-central Illinois water-pressure fracturing of Pennsylvanian sandstones has increased the initial yields of some wells. In areas in which the unconsolidated material does not contain water-yielding sand and gravel deposits (fig. 6) and the sandstones are absent there are slight possibilities for obtaining water from fractured shales, limestones, or coal in upper Pennsylvanian rocks.

Large Groundwater Supplies

Development of groundwater supplies for municipal, industrial, and irrigation purposes requires technical advice and careful planning based on all available geologic and hydrologic data. The type, extent, thickness, depth, distribution, and water-yielding characteristics of aquifers should be determined in order to estimate the available quantity of water and plan proper well construction. Hydrologic data, such as yields of existing wells, pressure potential of various formations, and water quality, also should be determined as accurately as possible.

Information on regional geologic conditions pertaining to groundwater supplies at prospective well locations is available upon request from the Illinois Geological Survey. The Survey maintains a current file of subsurface information, including drillers' logs, samples of drill cuttings, and geophysical records from which specific data on formation characteristics for many areas in Illinois are available. Information on well yields, water levels, and water quality is furnished by the State Water Survey.

Domestic Groundwater Supplies

Development of groundwater supplies for domestic and stock use differ from municipal, industrial, and irrigation developments in three important aspects: 1) the quantity of water needed for domestic and stock purposes is considerably smaller and may, therefore, be provided from considerably thinner and less permeable aquifers, 2) the area within which a well can be constructed for domestic or stock purposes is normally small, usually a farmyard or a suburban lot, and 3) the cost of well construction must be low.

In south-central Illinois geologic conditions are not always favorable for obtaining private water supplies with drilled wells. In areas of thin drift underlain by non-water-yielding bedrock (figs. 6 and 7), dug wells are the most practical way of obtaining groundwater supplies.

Subsurface geologic conditions generally vary little within the limited area of an individual homesite or farm. However, there may be great changes in geologic conditions with increasing depth. Information on depth of aquifers is valuable for planning the type, depth, and size of the intended well.

Perhaps the most important considerations in locating private wells are those of sanitation and convenience. Wells should be placed with regard to geologic conditions, surface drainage, topography, and land usage so as to provide maximum protection from harmful bacteria and other objectionable inorganic material.

The following suggestions may be helpful in planning for individual or farm supplies:

1) Inventory the water requirements by estimating the amount of water needed for domestic use, stock use, milk cooling and washing, and fire protection.

2) Obtain all available information on the occurrence of water-yielding formations at the location. The maps in this report are designed to give a fundamental understanding of the occurrence and distribution of the water-yielding formations in this area, so that the most suitable type of well can be planned. If additional, more specific information is desired, address the Illinois State Geological Survey, Urbana, Illinois, giving: a) location of property by section, township, and range, b) intended use of the water supply, c) estimate of the quantity of water needed, and d) all information on existing wells on the property or on previous drilling attempts.

3) Select a well driller with a reputation for constructing wells that have been proved to be trouble-free. Make sure the driller is capable of properly handling the types of aquifers he may encounter at the location. If the well is to be finished in sand and gravel, select a driller experienced in setting well screens.

4) Check with the State Department of Public Health for regulations and suggestions on proper well construction and location and proper pump housing. The State Department of Public Health discourages the use of well pits on Grade A milk farms unless they are built to very rigid specifications. Properly constructed well pits are more expensive than other approved methods of pump installation.

5) Make periodic bacterial analyses of the water supply. Dug wells are more difficult to keep sanitary than are properly constructed drilled wells. Wells drilled into creviced dolomite and limestone formations are, however, also susceptible to bacterial pollution, particularly where the creviced formation is overlain by thin overburden.

Role of the Drilling Contractor

Much of the success of any drilled well depends on the skill and knowledge of the drilling contractor. A drilling contractor has certain duties and responsibilities to his customers:

1) The driller should provide an accurate log of the boring at the time it is completed. The log should include a description of the formations, information on the static water level, basic construction features of the well (length and size of well casing and screen, etc.), and an indication of the capacity of the well as determined by a pumping test. Copies of the driller's log should be filed with the Illinois Geological Survey. Log books may be obtained by drillers without charge from the Survey.

2) The well should be constructed in accordance with accepted safe sanitary practices. The top of the well should be constructed to prevent surface pollution from entering the well or seeping downward around the casing. It is also desirable that well construction allow for measurement of the depth to water without requiring removal of the pumping equipment.

3) The driller should endeavor to take full advantage of any water-yielding formations he may encounter. In areas where groundwater conditions are generally unfavorable, it takes a skillful driller to obtain the maximum amount of water from a poor formation. Where sand and gravel aquifers are used as a source of groundwater, the driller should select a well screen on the basis of size and sorting of the formation material. After construction the well should be properly developed. A properly screened and developed well in sand and gravel will not pump an objectionable amount of sand or silt during service.

4) It is desirable to save samples at 5-foot intervals for the total depth of drilling, especially for municipal, industrial, irrigation, and school wells. The Illinois Geological Survey files samples of drill cuttings received from drillers. The samples may be sent express collect to the Survey where they will be studied and kept on file for reference. Information obtained from samples is vital in effective rehabilitation of old wells.

COUNTY GROUNDWATER SUMMARIES

Detailed information on groundwater supplies in the counties of south-central Illinois is given in the following pages. These discussions supplement the geologic information shown in figures 6 and 7.

Bond County

Thin sand and gravel deposits suitable for the construction of drilled wells for farm and domestic supplies are present locally in a large part of Bond County (fig. 6). The valleys of East Branch of Shoal Creek and Beaver Creek contain thick sand and gravel deposits that are suitable locally for large groundwater supplies. Testing is needed, however, to determine the presence of suitable sand and gravel deposits in the river flats.

In the western and northeastern parts of the county the glacial drift is thin and the bedrock in many places is at the surface. Here wells are finished in the upper Pennsylvanian bedrock.

In the middle of the county, a preglacial valley (fig. 6) contains unconsolidated material 100 to 175 feet thick. Although the character of the unconsolidated material in the valley is not known, sand and gravel deposits suitable for the construction of wells for domestic, farm, and larger supplies may be present. Further exploration is warranted in this area.

Water for farm and domestic supplies is obtained from shallow Pennsylvanian sandstones at depths ranging from 100 to 300 feet in the northeast part of the county and at depths ranging from 60 to 130 feet below land surface in the area of Beaver Creek in the southern part of the county.

Clark County

Glacial deposits in the central and western parts of Clark County are generally thin and not suitable for development of sand and gravel wells. In the southeastern part of the county, along the Wabash River valley, thick permeable deposits of sand and gravel that are potential sources of groundwater for industrial supplies are present. The presence of a buried valley in the southwestern part of the county is indicated by records of scattered wells that have encountered thick drift in the area outlined by dashes on figure 6. It is possible that sand and gravel suitable for large groundwater supplies may be located by testing in the area.

Groundwater generally is available from sandstone strata in the upper part of the Pennsylvanian system in the western two-thirds of the county. In this area wells usually obtain domestic supplies from the sandstone and, in some places, limestone strata in the upper 200 feet of the bedrock. In the eastern part of the county, sandstone is not reported except for a small area east and south of Weaver in the northeastern corner. Between Melrose and West Union in the southeastern part of the county, thin limestones are the source of groundwater for domestic and farm supplies.

Clay County

Thick permeable deposits of sand and gravel are present in the partially buried valley of the Little Wabash River in the eastern part of Clay County. These sand and gravel deposits are potential sources of groundwater for municipal and industrial supplies. Thin discontinuous deposits of sand and gravel are locally present in the bottomlands of the creeks and rivers adjacent and tributary to the Little Wabash River. In the western two-thirds of the county, where the glacial materials are relatively thin and bedrock crops out in many places, the chances of obtaining groundwater from sand and gravel with drilled wells are poor.

In the northern, eastern, and southern parts of the county groundwater supplies for farm and domestic use can be obtained from Pennsylvanian sandstones at depths generally less than 200 feet. In most of the central and east-central parts of the county, sandstones are generally missing. However, in a limited area east of Louisville a few wells obtain small supplies from thin Pennsylvanian limestones at shallow depths.

Clinton County

Thick deposits of sand and gravel, which are potential sources of groundwater for municipal and industrial supplies, are present in the partially buried preglacial valley of the Kaskaskia River. Continuous sand and gravel deposits are present in the area of Bartelso, Albers, and Germantown. The partially buried preglacial valley of Shoal Creek in the center of the county and the

buried Sandoval Valley in the eastern part of the county (fig. 6, area outlined by dashes) are potential local sources of groundwater for municipal and industrial supplies. Deposits of glacial drift up to 150 feet thick are present in these valleys and thick sand and gravel deposits have been reported in oil and coal tests. Test drilling is necessary, however, to locate suitable sand and gravel deposits.

Throughout most of the county, water for farm and domestic supplies is obtained locally from thin sand and gravel deposits. These deposits are discontinuous, however, and their groundwater possibilities vary within short distances.

Pennsylvanian sandstones, coals, or fractured shales and limestones are a local source of water for small farm supplies throughout the county. Water-yielding sandstones are present at depths ranging from 50 to 200 feet in the areas shown by double patterns in figure 7.

Crawford County

In the buried and partially buried valleys in the western part of Crawford County, thick deposits of permeable sand and gravel are potential sources of groundwater for municipal and industrial supplies. In the area outlined by dashes in figure 6, thick drift is reported and several wells obtain large groundwater supplies from sand and gravel. The area appears worthy of testing for municipal and industrial supplies. The broad, flat bottomlands along the Wabash River in the northeastern part of the county are underlain by thick permeable deposits of sand and gravel, also potential sources of large quantities of groundwater.

Water-yielding Pennsylvanian sandstones are present throughout most of the county, with the exception of small areas in the north and southeast. Many domestic and farm wells obtain water from these sandstones at various depths down to a depth of 175 feet.

Cumberland County

In the bottomlands of the Embarrass River, particularly in the partially buried bedrock valley, thick deposits of sand and gravel are potential sources of groundwater for municipal and industrial purposes. Thin, discontinuous deposits of sand and gravel are present locally in the north-central and western parts of Cumberland County, in the bottomlands adjacent to Hurricane Creek and other small streams tributary to the Embarrass River.

Water-yielding Pennsylvanian sandstones occur throughout most of the county with the exception of small areas in the northwestern and southwestern parts of the county. The sandstones generally occur at depths of less than 150 feet.

Effingham County

Glacial deposits in central and western Effingham County are thin and not generally suitable for sand and gravel wells. In the eastern part of the county a preglacial valley (tributary to the preglacial Wabash River) contains thick deposits of sand and gravel capable of yielding groundwater for municipal

and industrial supplies (fig. 6). Thin, scattered deposits of sand and gravel are present along the bottomlands of the present Little Wabash River and its tributaries.

Groundwater is obtained from shallow Pennsylvanian sandstones throughout most of the county with the exception of local areas south and east of Effingham, in the northeastern part of the county, and in the southeast corner. Most of the fresh-water-yielding sandstones occur at depths of less than 150 feet. However, in a small area in the south-central part of the county they occur at depths ranging from 150 to 300 feet.

Fayette County

Sand and gravel deposits favorable for domestic and farm supplies are widespread throughout most of Fayette County. In the partially buried valleys of the Kaskaskia River and Hurricane Creek and in the bottomlands along the Kaskaskia, thick deposits of sand and gravel are favorable sources of water for industrial supplies. Domestic and farm supplies of groundwater are generally available from shallow Pennsylvanian sandstones throughout most of the county with few local exceptions. Throughout most of the area these sandstones are present in the upper 50 to 150 feet, with a few occurring as deep as 200 feet.

Jasper County

Glacial deposits throughout most of Jasper County are thin and bedrock crops out at many places, particularly in the central part of the county. In the northeastern part relatively thick deposits of sand and gravel are associated with the partially buried Embarrass River Valley and are potential sources of large quantities of groundwater. Thin discontinuous sand and gravel deposits are present locally in the bottomlands of the present Embarrass River and in the bottomlands of small streams in the southwestern part of the county.

Sandstone aquifers in the Pennsylvanian system are water-yielding in the eastern and northwestern parts of the county. East of Newton these sandstones are at depths of 100 to 300 feet below land surface, and in the northwestern part of the county wells obtain water in the upper 100 to 150 feet of bedrock.

Lawrence County

In the bottomlands and partly buried valleys of the Embarrass and Wabash rivers, thick deposits of permeable sand and gravel are sources of groundwater for municipal and industrial supplies. Some thin, scattered sand and gravel deposits occur along the smaller tributaries of these larger streams. In the western and central parts of the county the glacial drift is thin and for the most part is not suitable for the construction of drilled wells.

Pennsylvanian sandstones are water-yielding throughout most of Lawrence County, with the exception of a small area in the north-central part. Most domestic and farm wells outside the areas of the Wabash and Embarrass rivers obtain water from sandstones at depths of 100 to 300 feet below the surface.

Macoupin County

Sand and gravel deposits are rare in the thin glacial drift so that chances of obtaining groundwater supplies with drilled wells above bedrock are poor. Sand and gravel deposits are present locally in the valleys of Otter Creek and Bear Creek and in the partially buried valley of Macoupin Creek. In most of the county, water from the drift is obtained with large-diameter dug wells. Because seasonal variations in water levels affect these shallow wells they should be made as deep as possible in the glacial drift, preferably to the top of the bedrock.

In the northern part of the county, water for farm and domestic supplies is obtained from shallow Pennsylvanian sandstones at depths ranging from 70 to 200 feet below land surface. Because of the unfavorable groundwater possibilities in the drift it is recommended that wells be drilled into the upper 50 to 150 feet of bedrock throughout the county. Domestic and farm supplies may be obtained locally from thin sandstone beds or from fractured shales, coals, and limestone beds.

Madison County

Excellent water-yielding sand and gravel deposits suitable for the construction of high-capacity wells occur at many places in the Mississippi River Valley at depths below 50 to 75 feet. Because of lateral variations in texture within the river sediments, construction of high-capacity wells at any particular site should be preceded by a small-diameter pilot hole to test the suitability of the deposits. Drillers report that sand and gravel deposits are thin and discontinuous in a band at the base of the bluffs, especially in the area southwest of Glen Carbon. In the area of Horseshoe Lake, the valley fill is composed mostly of fine sand and is not as favorable a source of water as in other parts of the valley. Details on the river sediments in the Mississippi bottomlands are given in Illinois State Geological Survey Report of Investigations 191.

In the flats of both the East Fork and West Fork of the Wood River and of Cahokia Creek, sand and gravel deposits are favorable local sources of groundwater for domestic, farm, and larger supplies, but locating suitable sites for wells may require extensive testing.

Thin deposits of glacial drift are present on the upland throughout Madison County. In some places thin beds of sand and gravel within the till may furnish enough water for small domestic supplies. These local sand and gravel deposits generally are found near the base of the till but because of their discontinuity they cannot be predicted prior to drilling. Many of the wells on the uplands are large-diameter dug wells that penetrate to the base of the loess and obtain water at the contact between the loess and the underlying till.

The bedrock, although in part capable of producing large quantities of groundwater, is of negligible importance in the Mississippi Valley flat because of the excellent possibilities in the shallower sand and gravel deposits. On the upland, however, in many areas the bedrock is the only groundwater source.

Thin sandstone beds, present in the Pennsylvanian system in general, are suitable only for domestic supplies. The Mississippian limestones and sandstones are favorable sources of groundwater where they are encountered at

shallow depths. The St. Louis limestone is a favorable source of water for farm and domestic supplies west of Godfrey, where it is encountered immediately below the drift, and in the area between Godfrey and Fosterburg, where it is encountered at depths ranging from 125 to 175 feet below land surface. In Ts. 3, 4, 5, and 6 N., R. 8 W., Pennsylvanian and Chester sandstones are potential sources of groundwater, and wells are finished at depths ranging from 100 to 400 feet below land surface. In the southeastern part of the county, wells are finished in Pennsylvanian sandstones at depths ranging from 100 to 250 feet below land surface.

Marion County

Sand and gravel deposits are scarce over much of Marion County, particularly in the eastern and southern parts where the drift is thin. Bedrock crops out in many places throughout the county.

A buried valley is present in the west-central part of the county (fig. 6, area outlined by dashes). This valley has thick deposits of unconsolidated material, and scattered well records report the presence of thick sand and gravel. Although the character of these sand and gravel beds is not known, the area is worth exploring for industrial and municipal supplies. Thin, discontinuous deposits of sand and gravel are associated with tributary streams of the Kaskaskia River in the northwestern part of the county.

In limited areas Pennsylvanian sandstones are a source of groundwater, particularly southeast of Salem. Where the sandstone occurs (fig. 7), farm and domestic supplies may be obtained from the upper 150 feet of the bedrock or, locally, in the upper 200 feet.

Monroe County

Thick deposits of sand and gravel suitable for municipal and industrial supplies are present in the Mississippi Valley flat with the exception of a narrow band at the base of the bluff, where sand and gravel deposits are discontinuous. Because of variations in texture within the river sediments, construction of high-capacity wells at any particular site should be preceded by testing to locate suitable sand and gravel deposits. (Details on the river sediments in the Mississippi bottomlands are given in Illinois State Geological Survey Report of Investigations 191). The upland is covered by thin glacial deposits that are unfavorable for the construction of drilled wells.

Wells drilled into the bedrock obtain water from limestones and sandstones of the Mississippian system. The St. Louis limestone, which forms the sinkhole topography north and south of Renault and west, southwest, and northwest of Waterloo, is the source of water for a large number of domestic and farm supplies throughout the county. This formation is encountered immediately below the surface or below a thin cover of glacial drift in Ts. 2, 3, and 4 N., R. 10 W., and dips eastward to depths ranging from 300 to 500 feet below land surface in T. 3 S., R. 8 W. Because of the danger of pollution in wells that penetrate shallow cavernous limestone, wells in the St. Louis formation must be constructed with special attention to sanitary practices (Education Health Circular 14, Department of Public Health, Springfield). The Burlington-

Keokuk limestone, which is encountered at depths ranging from 200 to 500 feet below land surface in the central and the western parts of the county, is a possible source of groundwater for farm and domestic supplies although it is less creviced than the shallower St. Louis limestone.

In the eastern part of the county the Aux Vases sandstone is a favorable source of groundwater for domestic and possibly larger supplies. This formation is encountered immediately below the drift, that is, at depths ranging from 15 to 30 feet below land surface, in the southern part of T. 3 S., R. 9W., and in the north part of T. 4 S., R. 9 W. In T. 3 S., R. 8 W., the Aux Vases is present at depths ranging from 260 to 300 feet below land surface.

Although the St. Louis limestone, the Burlington-Keokuk limestone, and the Aux Vases sandstone are the best aquifers in the bedrock of Monroe County, other Mississippian limestone and sandstone formations may be a source of water for farm and domestic supplies.

In the western part of the county, along the Mississippi Valley flat, Ordovician limestone and dolomite underlies the valley-fill material. These formations are potential sources of groundwater but have not been exploited due to the excellent possibilities in the shallow sand and gravel deposits.

Montgomery County

Sand and gravel deposits that may be suitable groundwater sources for private supplies are reported at many locations in the county. Many of the sand and gravel deposits occur in narrow discontinuous northeast-southwest belts. Several of these deposits have been developed as sources of water for villages, such as Waggoner, Nokomis, Raymond, and Stonington (Christian County). The bottomlands of the Shoal Creek East Fork locally may contain thicker sand and gravel deposits, but testing is necessary to locate favorable deposits in the river flat. The drift is thin and water-yielding sand and gravel are rare in areas along Shoal Creek east of Virden, east of Raymond, and southeast of Hillsboro, as shown in figure 6.

Pennsylvanian sandstones are the source of groundwater for domestic and farm supply in the central and south-central parts of the county where they are present from depths ranging from 100 to 180 feet below land surface. In the northwestern part of the county water-yielding sandstone is present at depths ranging from 70 to 120 feet below land surface. Well records show that west of Litchfield sandstone is present at a very shallow depth, that is, from 20 to 40 feet below land surface.

Richland County

The glacial deposits over most of Richland County are thin and lacking in sand and gravel. Local areas, such as the bottomlands of the Fox River and the tributaries of the Little Wabash River at the extreme western edge of the county, contain thin, scattered deposits of sand and gravel that should supply groundwater for farm and domestic use.

Pennsylvanian sandstones are present throughout most of Richland County except in the northwest corner (fig. 7). They yield fresh water at various depths from just beneath the drift (30 to 60 feet) to a maximum depth of 400

feet at a few localities in the east-central part of the county. Supplies for domestic and farm use generally can be obtained from these sandstones.

Shelby County

Throughout much of Shelby County domestic supplies of groundwater are available from discontinuous deposits of sand and gravel associated with the glacial deposits. High-capacity sand and gravel wells are constructed in the buried bedrock valley of the Kaskaskia River. Locally the glacial deposits are thin (fig. 6) and do not yield water.

In the central part of the county east of Shelbyville, groundwater is obtained from shallow Pennsylvanian sandstones at depths ranging to 150 feet. In the general area between Mode and Stewardson in the southern part of the county, water has been obtained from sandstones as deep as 200 feet below the surface. Lack of information in much of Shelby County prohibits precise determination of the depths from which fresh water may be obtained from these sandstones. Pennsylvanian sandstones appear to be absent in the western part and a portion of the eastern part of Shelby County (fig. 7).

St. Clair County

Excellent water-yielding sand and gravel deposits suitable for the construction of high-capacity wells occur in the Mississippi River flat. These deposits generally are present below a depth of about 50 feet. In a narrow band at the base of the bluff, sand and gravel deposits are discontinuous. Because of variation in texture within the river sediments, construction of high-capacity wells at any particular site should be preceded by testing to locate suitable water-yielding sand and gravel. (Detailed data on the river sediments in the Mississippi bottomlands are given in Illinois State Geological Survey Report of Investigations 191.)

Sand deposits are present at a shallow depth in the flat of Silver Creek and its tributaries. The deposits are locally a favorable source of groundwater for domestic, farm, and larger supplies. The water supply for the town of Lebanon is obtained by wells drilled in the Silver Creek bottoms. The Kaskaskia River flat in the southeastern part of the county contains deposits of sand and gravel that are worth exploring for municipal and industrial supplies.

On the upland the glacial drift is thin and does not contain sand and gravel deposits favorable for the construction of drilled wells. Thin sand and gravel beds are present locally in the lower part of the drift but their presence cannot be predicted prior to drilling. Wells dug to the base of the loess or to the base of the drift are the source of groundwater for some farm and domestic supplies throughout the county.

Where the drift is thin and underlain by Pennsylvanian rocks, domestic and farm supplies are obtained from shallow sandstones and creviced limestones, Wells in the Pennsylvanian formations range in depth from 80 to 200 feet below land surface.

The Mississippian Chester sandstones are potential sources of groundwater either where they are present immediately below the drift or where they are overlain by Pennsylvanian beds (fig. 7). Wells are finished in these sandstones

at depths ranging from 50 to 500 feet below land surface. Industries located in Belleville obtain water supplies from wells drilled into Mississippian sandstones at depths ranging from 400 to 600 feet below land surface, and the former municipal supply of Belleville was obtained from wells drilled 500 to 600 feet into Chester formations.

In the western part of the county the Mississippian-Valmeyer (fig. 7) formations are a source of groundwater for private and larger supplies. The St. Louis limestone, which forms the sinkhole topography south of Stolle, is a potential water source in St. Louis and in the region between Prairie du Pont Creek and the Mississippi River. Because of the danger of pollution in wells that penetrate shallow cavernous limestone, wells in the St. Louis formation must be constructed with special attention to sanitary practices (Education Health Circular 14, Department of Public Health, Springfield).

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Wells, dug, drilled, driven: Illinois Dept. of Public Health Circ. 14, 1951.

Other general reports on groundwater geology in Illinois similar in purpose and scope to the present study include the following circulars: C. 192, Water wells for farm supply in central and eastern Illinois; C. 198, Groundwater possibilities in northeastern Illinois; C. 207, Groundwater

in northwestern Illinois; C. 212, Groundwater geology in southern Illinois; and C. 222, Groundwater geology in western Illinois - north part. These circulars, published by the Illinois State Geological Survey, are available free upon request.

Topographic maps are available for most of the area covered in this report. These maps are on a scale of approximately 1 inch to the mile, but in the East St. Louis - Alton area they are available also on a scale of approximately 2 1/2 inches to the mile. They are printed by quadrangles and may be obtained from the Illinois State Geological Survey, Urbana, Illinois, or from the United States Geological Survey, Washington 25, D. C., for 20 cents each. Index maps showing the topographic map coverage of the state are free on request.

Detailed geologic reports have been published for the following quadrangles: Baldwin-New Athens, Belleville-Breese, Carlinville, Carlyle-Centralia, Crystal City-Kimmswick, Gillespie-Mt. Olive, New Athens-Okawville, Waterloo-Renault. Information on these reports may be obtained from the Illinois State Geological Survey in Urbana.

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CIRCULAR 225

ILLINOIS STATE GEOLOGICAL SURVEY

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